NASA Office of Aeronautics and Space Transportation Technology
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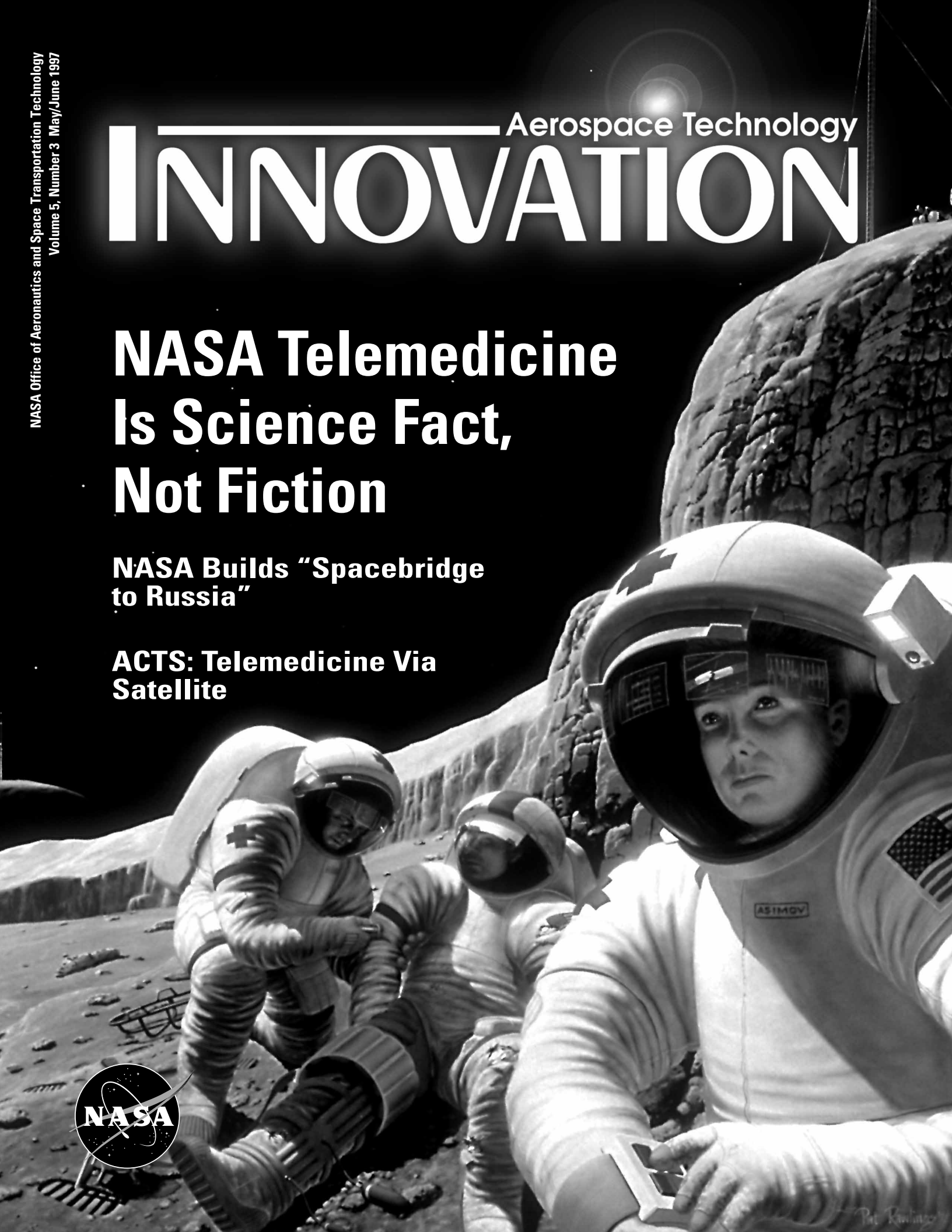
Aerospace Technology

INNOVATION

NASA Telemedicine Is Science Fact, Not Fiction

NASA Builds "Spacebridge to Russia"

ACTS: Telemedicine Via Satellite



Aerospace Technology
INNOVATION

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About the Cover:

NASA has a strategy to meet the challenge of delivering health care to astronauts in space as missions are likely to be farther away from Earth in the new millennium. The Agency will collaborate with academia, industry and other government agencies to leverage technologies to support mission needs. Humans living in remote locations on Earth who need medical care will benefit from these new advances as they already do from current NASA telemedicine technologies.

On-Line Edition: Go to **http://nctn.hq.nasa.gov** on the World Wide Web for current and past issues.

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COMMERCIAL DEVELOPMENT MISSION UPDATE

Date*	Flight	Payload	Sponsor/Coordinator
7/97	STS-94 MSL-01 Reflight	Astro-Plant Generic Bioprocessing Apparatus Vapor Diffusion Apparatus (Microgravity Research, including two proteins for structure-based drug design related to Chagas' Disease)	BioServe Space Technologies Center for Macromolecular Crystallography
9/97	STS-86** Shuttle/Mir-07	Commercial Generic Bioprocessing Apparatus Liquid Phase Sintering (samples going to Mir)	BioServe Space Technologies Consortium for Materials Development in Space
1/98	STS-89** Shuttle/Mir-08 Shuttle/Mir-08	Materials In Devices as Superconductors ASTROCULTURE™ X-ray Detector Test	Langley Research Center Wisconsin Center for Space Automation and Robotic Center for Macromolecular Crystallography

Key STS—Space Transportation System

*As of May 1997
**These payloads go over to Mir for extended operations of about four months and return on the next Shuttle/Mir mission.

WELCOME TO INNOVATION

Telemedicine—NASA's Perspective

by Charles R. Doarn
Program Executive, Aerospace Medicine

NASA HAS BEEN PIONEERING THE DEVELOPment and application of telemedicine since the Agency's beginnings. Challenged by the need to monitor the health status of astronauts in the remote and extreme environments of space, NASA adapted and further developed biotelemetery to obtain critical biomedical information. Telemedicine has long been a significant tool, linking astronauts on space platforms such as the Space Shuttle and Shuttle/Mir to medical personnel on the ground. Private medical conferences between individual astronauts and their crew surgeon are conducted on a scheduled basis during space missions. During select activities, such as extravehicular activities and biomedical research, physiological parameters, including heart rate, ECG, oxygen consumption and several environmental parameters, are monitored by a biomedical team at NASA's Johnson Space Center.

NASA'S STRATEGIC PLAN SERVES AS THE FOUNDATION FOR DEVELOPING COLLABORATIONS AND FOSTERING ADAPTATION AND INTEGRATION OF TELEMEDICINE TECHNOLOGIES INTO BOTH SPACE FLIGHT OPERATIONS AND TERRESTRIAL APPLICATIONS.

Delivering health care in remote locations such as space is challenging. The challenges include constraints on resources (for example, power, volume, and weight), resupply, training of the inflight crew medical officer (who may not be a physician), crew time on orbit for operations and maintenance, and technology adaptability to withstand the rigors of space flight. NASA astronauts represent the healthiest of humans; therefore, disease and illness are minimized. However, it is paramount that appropriate medical care systems are in place to address illness and injury should they occur.

As the dawn of the new millennium approaches, human exploration of space will be characterized by the operation of the International Space Station and human missions to Mars. A return to definitive medical care during these future missions will be delayed because of the significant distance from Earth. It may be impossible in some cases to return in time to affect change in health status. Men and women who participate in these exploration-class missions will become more autonomous than the current cadre of astronauts. Technologies in telecommunications and information systems, noninvasive medical technologies and new protocols and procedures must be developed to provide in-flight medical support during these types of missions. Thus, NASA has developed a strategic plan that guides the Agency's activities in telemedicine.

NASA's strategic plan serves as the foundation for developing collaborations and fostering adaptation and integration of telemedicine technologies into both space flight operations and terrestrial applications. Today, NASA is forming partnerships with academia, industry and other governmental entities to leverage technology and resources to support mission needs. Through the development of a commercial space center and partnerships with the Technology Transfer Centers, technology used to support in-flight medical care will serve to meet NASA's needs and capitalize on industry involvement to cross-fertilize ideas and concepts.

Telemedicine only recently has become a household word, although its notion has been around for many years. Approximately 10 programs existed in 1990. Several hundred programs today are conducted worldwide with millions of dollars spent. The technology used to support these activities varies from expensive, dedicated telemedicine studios to robust desktop or portable workstations.

NASA's achievements from its endeavors are about life on Earth. The challenges that we face as space explorers have resulted in technological breakthroughs that have enhanced the quality of life for all humanity. The evolution of medical care in space through the integration of telecommunications, information technologies and microelectronics, nanoelectronics and picoelectronics will revolutionize medical care throughout the world in the 21st century. ✪

A special note of thanks to Shaik Mazharullah, M.D., and the National Technology Transfer Center for their contributions.

TELEMEDICINE

Advanced Technology

Applications

Terrestrial Benefits

Strategic Direction

NASA RECENTLY RELEASED ITS *INTEGRATED Strategic Program Plan (ISPP) for Telemedicine: Advanced Information Technologies for Health Care.* It outlines the Agency's commitment to enhancing its capability to provide medical care in support of human space flight and the Human Exploration and Development of Space (HEDS) Enterprise and to leverage information systems and telecommunications technologies for health care. The Office of Life and Microgravity Sciences and Applications at NASA Headquarters directed the plan's creation with input from the NASA Field Centers, the National Technology Transfer Center and the Regional Technology Transfer Centers.

The plan recognizes that the primary purpose of NASA's telemedicine initiative is to enhance the health and well-being of astronauts during space flight. However, it underscores the need to apply telemedicine technologies to aid patients who have little or no access to medical care on Earth. The ISPP states:

The Application of telemedicine has permitted NASA to monitor the physiological and medical impact of space flight on astronauts. As mission profiles increase in duration, complexity, and distance from the Earth, health care systems for space flight will be enhanced to meet these challenges, including the integration of telemedicine technologies. The application of NASA technology on a global scale will help build a better future for all of humanity.

The ISSP for Telemedicine:

- Promotes the use of advanced technology in the space program and the integration of telemedicine into the National Information Infrastructure and the Global Information Infrastructure
- Clarifies and articulates NASA's role in the development of telemedicine technologies and telemedicine applications
- Establishes a process through the creation of a Commercial Space Center for medical informatics and technology with academia and industry for enabling partnerships, evaluating emerging technologies, conducting testbeds and supporting the infusion of technology into space flight applications
- Promotes strategic directions in support of the goals of NASA's HEDS Enterprise
- Creates a basis for collaborations with industry and academia in the development of telemedicine and associated technologies through the exchange of ideas and shared technologies
- Creates a platform for encouraging the development of innovative technologies for health care delivery through the incorporation of NASA technologies
- Uses the International Space Station as a testbed for evaluating emerging technologies

The ISSP's strategies are:

- Develop and adapt revolutionary sensor, telecommunications, information and human-machine interface technologies that have the potential to enhance health care systems for human space flight
- Apply appropriate new health care systems technologies in direct support of human exploration and the development of space
- Develop and promote appropriate, cost-effective applications of new telemedicine and integrated health care technologies to make health care more accessible worldwide

The plan outlines the approaches and tasks necessary to execute each of these strategies.

For more information, contact Charles Doarn at NASA Headquarters. 202/358-0821, 202/358-3038, *cdoarn@hq.nasa.gov* Or visit: *http://www.it.hq.nasa.gov/~kmorgan/telemed_blue/welcome.html* Please mention you read about it in *Innovation.*

Telemedicine From NASA's Beginnings

AS WITH SO MANY OTHER PIONEERING initiatives, NASA's telemedicine efforts began nearly 40 years ago as a solution to a problem. Medical personnel at the Mission Control Center at Johnson Space Center (JSC) in Houston needed to be able to monitor astronauts' biomedical responses because they were in extreme and remote environments. Astronauts also had to have access to medical care even though they were thousands of miles away from the nearest hospital.

Enter telemedicine technologies. Telemedicine continues from Mercury in the early 1960s to Gemini, Apollo and Skylab through the current Space

Shuttle and International Space Station (ISS) Phase I missions (Shuttle/Mir). During Space Shuttle missions, astronauts have daily private medical conferences with the crew surgeon on Earth. Physiological parameters including heart rate, oxygen consumption, heat production and suit carbon dioxide levels, and environmental parameters are monitored by the biomedical team at JSC via biotelemetry.

These solutions in space also have applications on Earth. NASA foresees a revolution in global health care delivery through the application of telecommunications, computer, and microelectronic and nanoelectronic technologies to support revolutionary improvements in such delivery. NASA promotes, develops and uses advanced technologies to deliver health care that benefits space flight and enhances health care for everyone.

That development continues. Researchers are working on telemedicine applications that support U.S. astronauts aboard the Russian Mir space station and the ISS. NASA also has used its expertise in telemedicine and telecommunications to provide assistance to disaster-stricken areas of the world and to aid in the application of space-based technologies to terrestrial medical care. ✸

STS-81 Shuttle/Mir mission crew aboard Russian Mir space station.

For more information, visit the NASA Telemedicine Home Page at *http://www.it.hq.nasa.gov/~kmorgan/telemed_blue/welcome.html* or the NASA Telemedicine Gateway at *http://www.nttc.edu/telemed.html* Please mention you read about it in *Innovation.*

NASA TELEMEDICINE TIMELINE

1970
NASA applies space technology to Rural Papago Advanced Health Care Program, bringing medical care to Papago Indian Reservation, AZ.

1975
NASA uses Applied Technology Satellite-6 (ATS-6) to provide S-band television, education and support for agriculture and health in India.

Satellite technology (COSPRAS/SARSAT) supports international search and rescue efforts in Canada, France and the former Soviet Union.

NASA's ATS-1 and ATS-3 support Pacific Basin health care education efforts through PEACESAT.

1989
Spacebridge to Armenia/Ufa responds to December 1988 earthquake in Armenia and gas explosion in Ufa.

1993
University of Washington joins Lewis Research Center and Jet Propulsion Laboratory on a teleradiology project that uses Advanced Communications Technology Satellite.

Spacebridge to Moscow responds to October 1993 civil disturbances.

1994
NASA collaborates with University of Pittsburgh, WHO, PAHO, USAID and World Bank to organize Global Health Network, which provides tele-preventive medicine.

1995
Ames Research Center,Trident Inc. and Cedars Sinai Medical Center, Los Angeles, collaborate on a telemedicine demonstration project.

Telemedicine Technologies Across NASA

ORGANIZATIONS ACROSS NASA ARE INVESTIgating ways to bring telecommunications information technologies and medicine together to deliver health care not only to the astronauts but to the citizens of Earth who live in locations that are remote and have limited access to medical care.

Examples of these activities follow. Visit the NASA Telemedicine Home Page at *http://www.it.hq.nasa.gov/~kmorgan/telemed_blue/centers/centers.html* or the NASA Telemedicine Technology Gateway at *http://www.nttc.edu* for a more comprehensive list that includes links to project sites.

Virtual Reality/Robotics

Ames Research Center (ARC) and Stanford University Medical Center are developing a virtual environment workbench to plan complex craniofacial reconstructive surgery. The team is designing grid generation methods and computer software to combine laser scans with computer tomography and magnetic resonance imaging to make three-dimensional constructions of the face and head.

The surgeon plans reconstruction in this virtual environment by exposing the skull beneath the face to remove bone, cut it into appropriate sections and replace them. Soft tissues are replaced computationally, and facial features are remolded automatically to the new skull. Once the surgeon is satisfied, he or she uses the workbench to prepare for actual surgery.

Dr. Kevin Montgomery of Ames works the virtual environment boom. The glove on Montgomery's right hand allows him to manipulate the 3-D image on the monitor. Eventually, the glove will enable surgeons to "use" surgical instruments to practice surgery on the image.

The workbench also could be used to train craniofacial surgeons. More than 50 steps with specific tools must be followed in exact sequence. Trainees would sit before a computer screen and practice these steps before ever touching a patient.

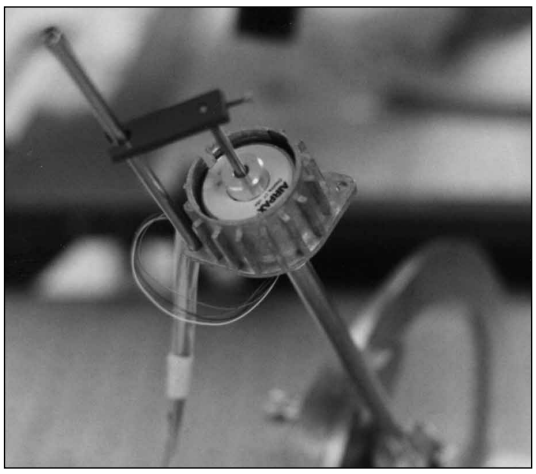
The workbench will be interactive. It will be capable of such interactions over long distances using high-speed networks and the Internet.

Marshall Space Flight Center's (MSFC) Virtual Reality Applications Program and EXOS Inc. of Massachusetts, now a Microsoft company, collaborated on a Sensing and Force-Reflection Exoskeleton (SAFiRE). SAFiRE senses hand and finger motion as human operator input and provides force-reflective feedback to the operator for both telerobotic and virtual environment applications. EXOS Inc., under a NASA Phase II Small Business Innovation Research (SBIR) project, produced an exoskeleton worn on the hand and forearm that senses motion and applies forces to the thumb, index finger and wrist. The SAFiRE project's technology base could be used to develop a biomechanically sound resistance exercise system with a passive motion option for the hand and wrist.

ARC and Stanford University, through the Neurosurgical Computational Medicine Testbed, are developing a neurocontroller, which is a robotic probe that "learns" the physical characteristics of the brain, giving surgeons finer control of surgical instruments during delicate brain operations. The robotic probe learns the brain's characteristics by using neural net software, the same type of technology that helps focus camcorders. The probe, equipped with a tiny pressure sensor, will enter the brain, gently locating the edges of tumors while preventing damage to critical arteries.

The robotic probes are much smaller than standard probes and should further reduce potential brain damage. The smart computer program, which continues to learn as it gains more experience, controls speed and maximum pressure during the robotic neural net procedure. If the probe hits an artery, it will stop before it penetrates so the surgeon can decide what to do next.

ARC is developing robotic telepresence surgery to address medical emergencies that may occur



The Neurosurgical Computational Medicine Testbed is a simple robotic device that may be used someday in human brain surgery.

during long-duration human space flights. A surgeon on Earth could control the surgery by issuing high-level commands to the robot.

Remote Diagnosis

ARC and the University of Maryland School of Medicine are examining the cognitive demands of differing types and experience levels of patient care providers in the Remote Diagnosis for Trauma Patient Resuscitation study.

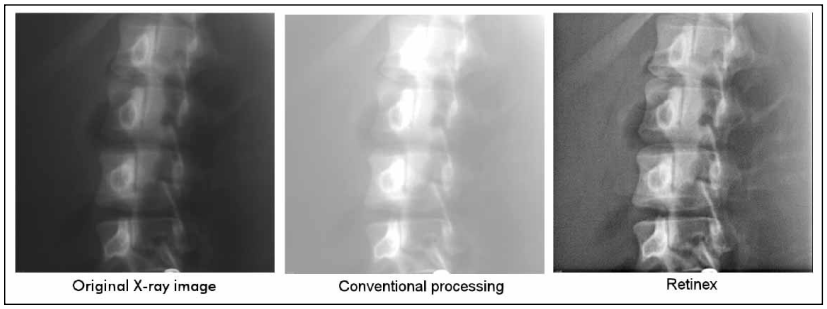
Variables manipulated in the initial study involved the amount and type of information presented to the remote decision maker, including real-time vital sign overlay and case history description level. The study has assembled a library of videotapes of actual shock-trauma cases. The cases selected for study differ in problem type, diagnosis ambiguity, off-camera events and error recovery. Initial data collection shows certain types of patient condition judgments are difficult to assess (such as the extent of injury), and many important cues are missed because of the video medium. Diagnostic strategies include using correlated information to compensate for the lack of complete data and relying on secondary cues reflected in team activities. The results to date indicate the importance of rich case history descriptions and the difficulty of maintaining a dynamic patient model, perhaps from not being in the control loop.

Military, disaster aid, search-and-rescue teams and doctors with rural patients could use ARC's Automation and Support System for Expert Telescience (ASSET), a real-time intelligent advisor that makes quick decisions on the significance of incoming data, to diagnose and treat patients in remote locations. ASSET was developed to improve the real-time engineering/scientific return of measurements/experiments by providing the software operator with an "intelligent assistant" that encapsulates much of the relevant knowledge mastered by the project expert. ASSET's several modules together collect, calibrate and quality monitor data, diagnose data-collection problems, monitor and formulate hypotheses, determine and schedule session steps and provide general-purpose help to the operator. These modules could be used together or separately for a specific application.

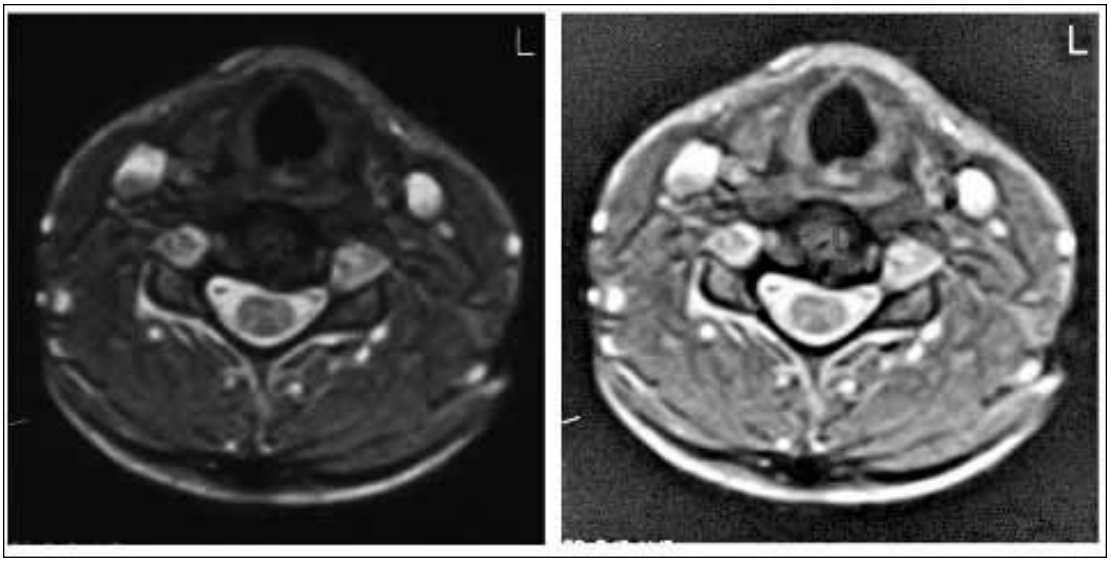
Image Compression and Enhancement

High Performance Data Compression (HPDC) developed by Goddard Space Flight Center will reduce images to a fraction of their original size by a 10:1, 20:1 or even higher compression ratio. Decompressed data have some distortion, yet this technique offers the quick-look capability from a large format sensor and allows scientists to perform telescience by selecting areas of interest for further detailed observation. HPDC analysis and simulation results defined an algorithm that offers better image quality than the industry-standard JPEG compression scheme. HPDC can process a more dynamic and wider range of data than JPEG, and its implementation and operation are much simpler. HPDC uses already-developed lossless compression hardware.

ARC developed Super-Resolved Image Processing Software (S-RIPS) to improve the quality of images from space probes, but the technology could be applied to telemedicine conferences and medical imaging. S-RIPS creates a super-resolved



This photograph compares the application of Retinex image processing (right) to conventional processing (center) of a medical x-ray image (left).



Retinex image enhancement methods were developed for color but also are useful for black-and-white medical images, such as x-rays and MRIs. This photo shows an original MRI of a cervical spine at c6 vertebra (left) and the Retinex-processed image (right).

image, with both spatial and grayscale resolution improved, by using a number of source images of the same object from slightly different perspectives. As the number of digitized source images increase, the software produces even finer resolution images.

Retinex image enhancement methods developed at Langley Research Center, which are being commercialized for color, provide a graceful compression of visual information. This compression also is useful for black-and-white medical images, such as x-rays and MRIs.

Often, medically important visual phenomena are spread across a widely varying background exposure, obscuring clear visualization. The Retinex method restores all the visual information for a more accurate diagnostic interpretation. This method can be applied remotely on digital images and transmitted to any network location for a rapid examination by the appropriate specialist. The method also may be applied locally by a specialist, and the enhanced, interpreted images may be transmitted back to the physician or the originating laboratory.

Education

MSFC's Virtual Reality Applications Program is developing, evaluating and using an inexpensive virtual reality human cadaver software application for classroom anatomy instruction. The software will run on a Pentium-based personal computer. The detailed model will include subdivided organs, texture mapping and three-dimensional sound for the major organs. This immersive learning environment is expected to afford quicker recognition, orientation and retention in human anatomic instruction. This project could lead to other virtual reality science training applications.

ARC and MusculoGraphics, Inc., through the Advanced Research Projects Agency, are working on Surgical Simulation for Limb Trauma Management, an effort that will enable military surgeons to learn surgical procedures on realistic computer models, which will improve training for surgical trauma care. Recent computer software developments have enabled conventional two-dimensional medical imagery to be converted into detailed three-dimensional human anatomy representations. The team is creating three-dimensional computer limbs using this software. These realistic anatomical models can be manipulated to simulate specific wounds and wound treatments, allowing surgeons-in-training to gain "virtual" experience in a wide range of trauma scenarios.

The technology also can be used for collaborative telemedicine by transmitting three-dimensional images to experts in other locations. When connected to telemetry lines, the system can transmit anatomically accurate images to experts in rear-echelon hospitals, enabling medics to interact with experienced physicians.

ARC's Center for Health Applications of Aerospace Related Technologies (CHAART) expands the use of aerospace-related technologies for global

health monitoring by the human health community through training, education, application projects and the direct transfer of proven technologies and knowledge to research/control agencies and universities. Many of the parameters associated with environmental change and disease patterns can be sensed remotely by instruments aboard aircraft and satellites and modeled spatially with specialized computer software. Remote-sensing and geographic information system technologies can be used to pinpoint disease prevalence and patterns and a disease's occurrence in space and time.

Internet

The Jet Propulsion Laboratory and the Los Angeles County Center for the Vulnerable Child developed a Web-based system that enables fast turnaround on child abuse cases. The Virtual Center for the Vulnerable Child enables Internet-connected schools to use digital cameras to report suspected child abuse cases to a group of child abuse experts. Specially equipped remote clinics use telemedicine equipment, such as a videoconferencing system combined with a special dermatology scope, to perform exams in real time should further inspection be required.

The Aerospace Medicine Division at NASA Headquarters has teamed with the University of Pittsburgh to develop the Global Health Network (GHNet) using the World Wide Web. This worldwide network provides access to a plethora of data and information on a variety of medical and global health issues. GHNet also serves as a virtual university, providing interactive collaborations and communications to support medical education.

The Aerospace Medicine Division at NASA Headquarters and the Pan American Health Organization have established an Internet-based disaster preparedness network, linking health sector disaster preparedness offices in several Central American and South American countries with appropriate agencies within those countries and the region to strengthen disaster management, preparedness and response. This activity uses the Internet as a cost-effective tool for supporting the training of disaster response personnel in the host country.

Dryden Flight Research Center, Johnson Space Center, the University of Texas Health Sciences Center, Sprint and VTel launched a HOST-consortium project to bring advances in telemedicine to cancer-stricken children in medically underserved south Texas. HOST is a consortium composed of key players in the health care information systems industry. NASA helped provide two-way audio/video linkages so physicians in San Antonio could examine patients, review lab tests and consult primary care physicians at South Texas Hospital in Harlingen. South Texas lacks medical specialists in a number of areas, including cancer treatment, putting children in the region at a disadvantage. Prior to NASA's involvement, children in the area had to travel more than 250 miles to a San Antonio hospital to receive cancer treatments or wait for the one day a month that a specialist could visit their local hospital. ✱

Dr. Terry Lightner in Harlingen, Texas, transmits a child's heart beating to doctors at the University of Texas Health Science Center at San Antonio, 250 miles away. South Texas lacks medical specialists in a number of areas, including cancer treatment.

For more information about contacts for a specific project, contact Shaik Mazharullah at the National Technology Transfer Center. 800/678-6882. Please mention you read about it in *Innovation.*

NASA Builds "Spacebridge to Russia"

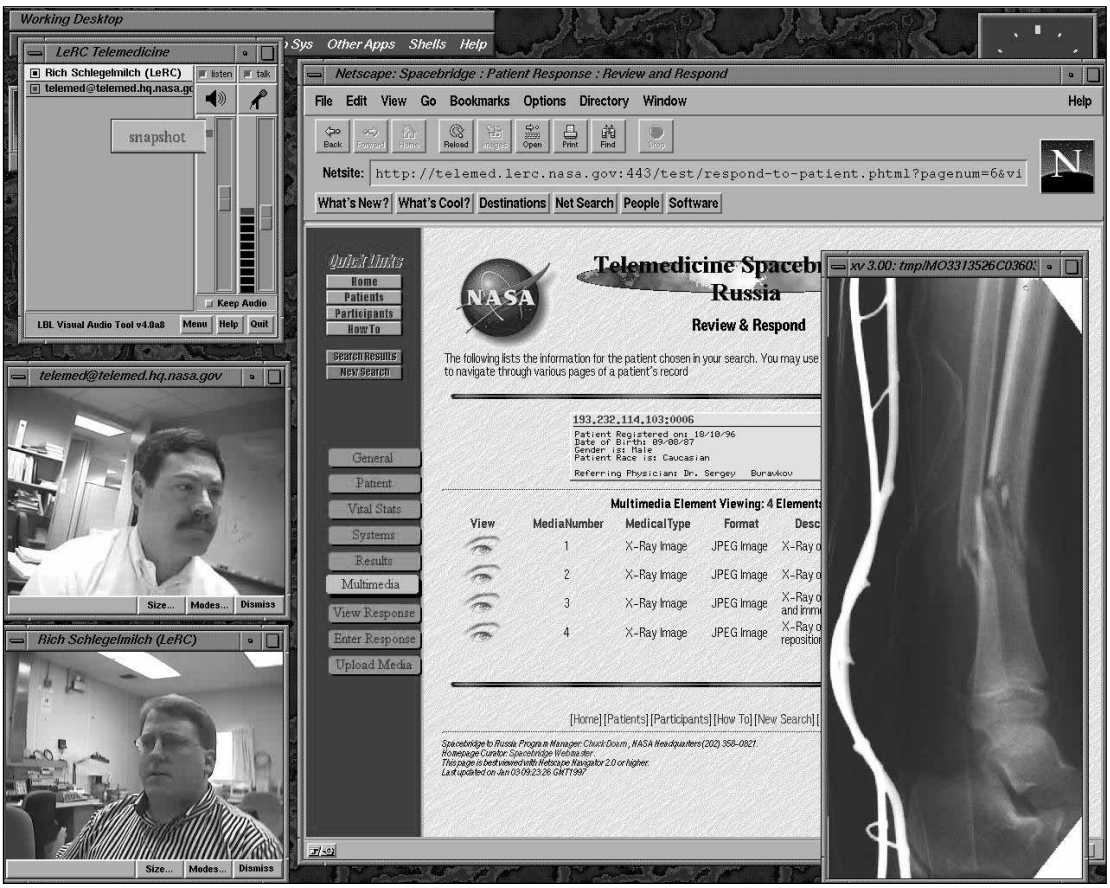
SOMEDAY, THE OLD-FASHIONED HOUSE CALL could return in a new-fangled format. Doctors and patients would meet via personal computer, which would mean no more sick patients trudging to the doctor's office.

Astronauts working on the Space Station would not be able to visit their doctors on Earth. Thus surfaced the necessity of Spacebridge to Russia, a NASA project that one day hopes to focus on home health care, whether home is on the Space Station or on Earth.

Right now, Spacebridge to Russia, a collaborative effort between NASA's Office of Life and Microgravity Sciences and Applications, Division of Aerospace Medicine and the Russian Space Agency, is working to further the development of an operational telemedicine system to support the human space flight program's medical activities. This work includes NASA's medical personnel in remote locations.

Spacebridge to Russia is an Internet-based telemedicine testbed that links academic and clinical sites in the United States and Russia via the Internet for clinical consultations and medical education. Using multimedia computers and Internet technologies, such as the World Wide Web and video teleconferencing, leading U.S. and Russian academicians have exchanged ideas in several medical disciplines. Coordination on the Russian side is performed by the Space Biomedical Center for Training and Research at Moscow State University.

Other U.S. and Russian sites are being integrated into this activity to evaluate telemedicine and medical education on the Internet. They include LDS Hospital, Salt Lake City, Utah; Fairfax Hospital, Falls Church, Virginia; Yale University School of Medicine and the Clinical Hospital of the Medical Department of the Ministry of Interior,



Spacebridge to Russia web site for patient presentation.

Moscow. Each site has a Silicon Graphics Indy computer workstation; certain sites have additional telemedicine support diagnostic tools. Also involved are IKI (Space Research Institute) and the Central Clinical Hospital of the Russian Federation's Government Medical Center.

Telemedicine in post-disaster response: Spacebridge to Armenia, a predecessor to Spacebridge to Russia.

The Ames Research Center developed the platform and provides network support for Spacebridge to Russia, specifically the incorporation of nonproprietary software for videoconferencing. The Lewis Research Center developed a World Wide Web graphical user interface for preparing case materials, such as patient medical records, images, audio and video. In most cases, data are stored first, then forwarded to another site. Yet, multimedia workstations, accessible through networks such as the Internet, provide a platform for conducting diverse clinical consultations via videoconferencing and whiteboarding.

Physicians may use these multimedia workstations to create and consult on clinical cases that are stored electronically in a relational database containing patient records. Physicians interact with the database over the Internet using a common web browser, such as Netscape Navigator. The patient databases are stored and mirrored on two servers—one located in the United States and the other in Moscow—to increase system response time.

The full integration of Internet services for use by NASA will one day allow clinicians to interact with each other and their patients via real-time video, audio and whiteboard while having simultaneous access to case-related information and medical education. In fact, NASA has developed a partnership between Baylor College of Medicine in Houston, Texas, and Moscow State University to use this infrastructure to support medical education. The Johnson Space Center has teamed with Baylor for a series of medical education lectures between Baylor and Moscow State University. Several lectures in a variety of disciplines already have been conducted using the Internet and the Spacebridge to Russia infrastructure. Lecture material is provided via a graphical user interface on the World Wide Web. ✸

For more information, contact Michael A. Cauley at Lewis Research Center. 216/433-3483, 216/433-8705, *mcauley@lerc.nasa.gov* Or contact Charles Doarn at NASA Headquarters. 202/358-0821, 202/358-3038, *cdoarn@hq.nasa.gov* Please mention you read about it in *Innovation*.

ACTS: Telemedicine Via Satellite

LARGE MEDICAL CENTERS IN URBAN AREAS can support small and medium-sized facilities in small towns and rural areas because of today's advanced communications technologies. Advanced communications satellites, such as Lewis Research Center's Advanced Communication Technology Satellite (ACTS), help provide quality medical diagnosis and information services to remote facilities in a faster, more cost-effective manner.

ACTS, the world's first processing Ka-band satellite, is pioneering new communications initiatives that apply to telemedicine. It uses small, low-cost portable antennas with affordable

high-data-rate (up to T1—1.544 megabytes per second) transmission of medical records, images and live video. A number of experiments have explored the telemedicine applications of ACTS.

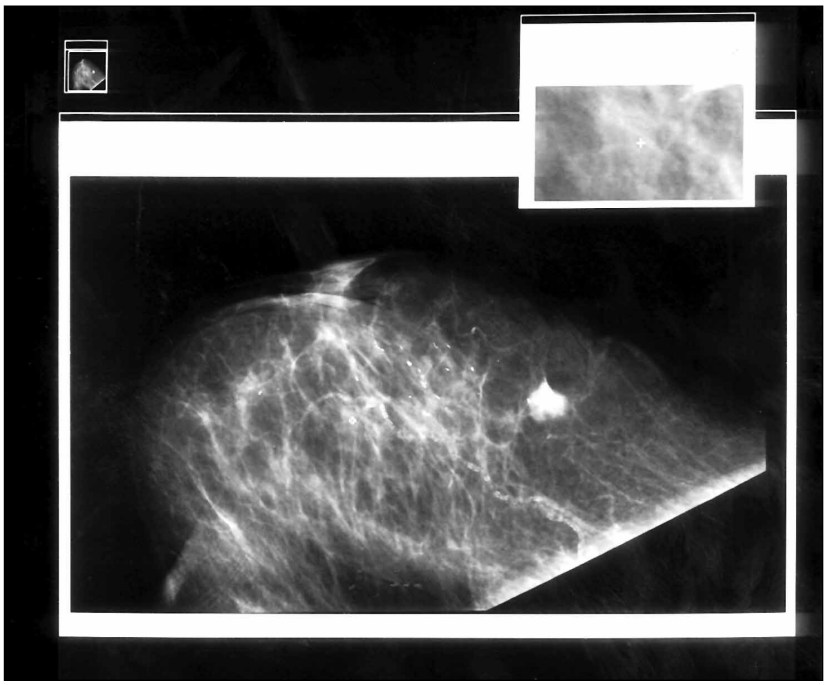
AMT Telemedicine Experiment

The University of Washington Department of Radiology's ACTS Mobile Terminal (AMT) Experiment, outfitted in a news-gathering van, was interfaced to a computer and a magnetic resonance-imaging device to provide medical-imaging files and remote diagnosis, respectively. The mobile terminal traveled throughout Washington State, with the fixed station at the Jet Propulsion Laboratory (JPL). The experiment demonstrated and evaluated a full-duplex voice, data and slow-scan video communications link for remote medical-imaging applications and characterized the K/Ka-band land-mobile propagation channel.

Telemammography Using Satellite Communications

This experiment demonstrated technologies and methods to deliver high-quality, high-resolution mammography images from rural to urban sites using low-cost, high-access global satellite networks. Digital image compression, satellite link performance requirements and satellite-to-terrestrial network interoperability must be developed while maintaining diagnostic accuracy and low system cost. The Cleveland Clinic and the University of Virginia are affiliated with the project.

This display is a digitized mammogram recently transmitted over ACTS. The area of interest is magnified to assist the radiologist in the diagnosis.



Advanced Applications to Validate ACTS Technologies

Several collaborative telemedicine, image-processing and educational projects, plus equipment checkout prior to the availability of an ACTS high-data-rate Earth station in Hawaii, were involved. Medical imagery files were exchanged with the University of Washington Medical School, and a prototype PC-based telemedicine terminal was checked out with Georgetown University. Other partners were the Pacific Space Center, the University of Hawaii, the State of Hawaii and GTE Telephone Company.

Application of Small Earth Stations in Conducting Telescience and Telemedicine

This Johnson Space Center (JSC) experiment showed that the satellite is an acceptable transmission medium to provide medical diagnosis on long-duration space flights. Fifty-three patients were viewed from another site in Houston, where physicians tried to accurately diagnose their ophthamological conditions with minimal questions. The patients previously received extensive eye exams. The only information provided for diagnosis was the patient's age, an eye problem synopsis and a telemedicine Fundescope eye examination. Doctors diagnosed 50 patients correctly and one incorrectly; two need further examination. KRUG Life Sciences Inc., the University of Colorado Health Sciences Center and Fitzsimmons Army Medical Center were involved.

EMSAT: Advanced Technology for Emergency Medical Services

JPL and EMSAT successfully demonstrated the use of the AMT for emergency medical communications. The experiment evaluated the feasibility of mobile satellite communications for better pre-hospital communications than are available with current terrestrial radio technologies. It assessed the transmission and reception of satellite digital voice for two-way, pre-hospital communications, one-way transmission of patient data from field

paramedics to the base hospital and telemetry of patient assessment data to the base hospital. The trials simulated communication with paramedics at the accident scene and en route to the hospital.

Medical Service Triage Support and Radiation Treatment Planning

This experiment combined telemedicine and supercomputing to compare teleradiology via the Internet or ACTS by digitally transmitting vast amounts of medical information and images. It also performed distributed radiation treatment planning, optimization, remote medical access and imaging for remotely computed dose calculations and volume visualization. The results were disseminated in real time for collaboration and treatment. Goddard Space Flight Center, University of Hawaii, Ohio Supercomputer Center and Georgetown University were involved.

Prototype Multimedia Telemedicine Testbed: Alaska as a Model (Project Ravencare)

This experiment demonstrated telemedicine for remote patient care. T1 VSATs linked Mt. Edgecumbe Hospital in Sitka, Alaska, to Georgetown University in Washington, D.C. The network was tested to ensure its provision of safe, reliable and optimized remote patient care for patients. One experiment included the transmission of digitally encoded x-rays for remote consultation. Interactive video, audio and text were integrated into the platform to provide enhanced consultation capabilities.

Medicine in an Integrated Group Practice

This Mayo Clinic Foundation investigation assessed the feasibility of delivering the diagnostic modalities necessary for high-quality health care, telemedicine's acceptance by providers and consumers, the seamless integration of new communications technologies into existing infrastructure and the rapid access and archiving of medical information by transparent repositories. An ACTS high-data-rate Earth station in Arizona was connected to Phoenix Children's Hospital and the Mayo Clinic in Scottsdale, Arizona. The Mayo Clinic in Rochester, Minnesota, was connected terrestrially to Sprint's MAGIC fiber optic network and linked to its Arizona counterparts over ACTS from the high-data-rate Earth station and MAGIC in Kansas City, Kansas.

Application of ACTS to the Practice of Medicine in an Integrated Group Practice

This Mayo Clinic Foundation experiment involved remote telemedicine studies and training using a variety of techniques, primarily with commercial T1 video teleconferencing equipment. It verified the value of T1 rate video and medical data telemetering for certain medical consultations and for continuing medical education and training classes.

ACTS Montana Telemedicine Demonstration

This demonstration used a modified version of the ACTS Ultra Small Aperture Terminal (USAT) with the portable Telemedicine Instrumentation Pack (TIP) developed by KRUG Life Sciences for JSC. The TIP, a briefcase-sized medical diagnostic system used in Space Shuttle missions, with USAT and ACTS can provide basic medical capability to any location. Others involved were St. Vincent's Hospital, Crow-Northern Cheyenne Hospital and Exxon's Billings Refinery.

In a staged telemedicine emergency situation at a remote Exxon refinery, a medical technician transmits vital information to St. Vincent's Hospital in Billings, Montana.

VAMA VSAT Access to Medical Image Archives

The National Library of Medicine and the University of California at San Francisco Medical School developed and evaluated a system for remotely accessing medical records and image databases, including the Visible Human collection and x-ray images collected as part of the National Health and Nutrition Surveys. Multisocket image retrieval software is being developed to use full T1 satellite channel speed while maintaining Internet compatibility. ✸

Contact Shaik Mazharullah at the National Technology Transfer Center for individual project contacts. 800/678-6882, *http://www.nttc.edu/telemed/lewis.html* Please mention you read about it in *Innovation*.

NASA and NTTC Partner With Telemedicine Industry

NASA IS WORKING DILIGENTLY TO PLACE ITS telemedicine technologies into the hands of U.S. business and industry. The Aerospace Medicine Division of the Office of Life and Microgravity Sciences and the Commercial Technology Division of the Office of Aeronautics and Space Transportation Technology (both at NASA Headquarters), the NASA Field Centers, the National Technology Transfer Center (NTTC) and the Regional Technology Transfer Centers (RTTCs) have worked together to plan and develop telemedicine technology transfer and commercialization initiatives using NASA-developed technologies.

NTTC supports this national initiative by collecting information from the Aerospace Medicine Division and each of the RTTCs and Field Centers to outline and coordinate all of NASA's telemedicine efforts for industry. NTTC began this effort in preparation for the Telemedicine Workshop it organized for NASA at Technology 2006. NTTC has disseminated this information through its NASA Telemedicine Technology Gateway at *http://www.nttc.edu/telemed.html* and through assisting 1,000 callers who requested NASA telemedicine information from NTTC's Gateway Services. NTTC also conducts technology assessment and commercialization reviews.

NTTC continues its work to bring NASA technologies to the telemedicine forefront through the following national telemedicine initiatives:

- **Telemedicine in Prison Systems:** NTTC, through the National Institute of Justice's Office of Law Enforcement Technology Commercialization, has joined with NASA's Lewis Research Center and the Ohio Correctional Technology Network to promote the applica-

TELEMEDICINE TECHNOLOGY AT ONE SOURCE

The National Technology Transfer Center (NTTC) brings space technology to the telemedicine industry through the NASA Telemedicine Technology Gateway. This is an information clearinghouse for NASA telemedicine technologies and initiatives.

The NASA Telemedicine Technology Gateway may be accessed on the World Wide Web (*http://www.nttc.edu/telemed.html*). The NTTC contacted each of the NASA Field Centers and Regional Technology Transfer Centers to compile their telemedicine information into one easy-to-reach source.

The NASA Telemedicine Gateway spells out NASA's telemedicine vision and goals and outlines the evolution of the space agency's telemedicine initiatives. Past and present applications of telemedicine technologies are showcased. The Gateway provides an in-depth look at NASA's telemedicine pilot projects, and its abstracts detail research on each of the other telemedicine projects under way at the NASA Field Centers.

The NASA Telemedicine Gateway also is a prime source for finding telemedicine technologies for which NASA is looking for partners. It has a number of links to other telemedicine resources and includes links to NASA TechTracS and the NASA Commercial Technology Network for more information about partnership opportunities with NASA.

A telemedicine information specialist at the NTTC is available to answer your questions about NASA telemedicine technologies. ✸

For more information, contact Shaik Mazharullah at the NTTC. 800/678-6882, *smazharullah@nttc.edu* Please mention you read about it in *Innovation*.

tion of NASA telemedicine technologies in prisons to provide cost-effective, safe, quality care to inmates.

- **Telemedicine in the Mining Industry:** NTTC and an Ohio Valley company are exploring opportunities to apply NASA telemedicine technologies to manage medical emergencies during a mine disaster.
- **Telepreventive Medicine Project:** NTTC, with NASA, actively participates in the activities of Global Health Network (GHNet), an alliance of health and telecommunications experts who are developing the health information structure for disease prevention in the 21st century.

NTTC also has advanced NASA telemedicine technologies in the Ohio Valley and tri-state region by:

- Establishing a regional working group with community hospitals, health maintenance organizations, and computer and telecommunications companies to assess the telemedicine needs of its generally rural region and to identify the adoption of NASA and other federal technologies to meet those needs
- Providing technical support from NASA scientists to a local hospital to establish a telemedicine network
- Working with Georgetown University Medical Center to leverage NASA telemedicine technologies into their telemedicine services, which include teleradiology, telepathology and telerenal dialysis ✿

For more information, contact Shaik Mazharullah, M.D., at NTTC. 800/678-6882, *smazharullah@nttc.edu* Please mention you read about it in *Innovation.*

NASA's Telemedicine Future: Terrestrial Benefits

UNTOLD DISCOVERIES WILL BE MADE AS A result of planetary exploration as we enter the 21st century. Humans traveling to Mars will require systems that provide for autonomous operation. These systems will have to be able to support the astronauts' every need, including medical care delivery.

NASA must adapt and/or develop appropriate technologies in medical informatics, smart medical and environmental sensors, decision support systems, image compression, new teaching aides, holography, virtual environments and noninvasive procedures. Information technologies will enhance on-board training so the crew medical officer and the crew engineer both can maintain their skills in many diverse areas.

These kinds of technologies will provide an opportunity for the crew medical officer to obtain vital information about crew members' physiological status without using invasive procedures. The ability to analyze blood without obtaining a blood sample has tremendous benefit in space flight and an even greater benefit on Earth. It reduces the consumables that need to be taken to orbit, and no reason would exist to return samples to Earth for postflight analysis. Similar technology also would benefit environmental sampling.

The development of these technologies will revolutionize medical practice. Telemedicine technologies used in the space program will be adapted to terrestrial medical practice, so the doctor may visit the patient much as he or she did in the 19th century. The exception, of course, is the doctor will have 21st-century technologies in his or her black bag.

Telemedicine on the Internet and access to health information will be commonplace by the year 2000. Today, people from all walks of life have access to more information than ever before because of the Internet. At the direction of Vice President Al Gore, several federal agencies, including NASA, are collaborating on the development of Next Generation Internet (NGI), an infrastructure that allows information to flow much faster than is now possible.

The technologies NASA is exploring today will be necessary to medical education and medical care in the future and serve as a foundation for fundamental change in the practice of medicine. The emergence of these technologies will further eliminate barriers to quality health care.

NASA will continue to share its knowledge, so as the Agency proceeds with its space exploration mission, we might better understand life's processes and how we might enhance quality of life.

For more information, contact Charles Doarn at NASA Headquarters. 202/358-0821, 202/358-3038, *cdoarn@hq.nasa.gov* Please mention you read about it in *Innovation.*

Hyper-X Pushes Flight Boundaries

NASA HAS SELECTED MICROCRAFT INC. OF Tullahoma, Tennessee, to lead a five-year project that will push the boundaries of aeronautics and develop new space technologies. The project, known as Hyper-X, will demonstrate hypersonic propulsion technologies. The team led by MicroCraft will fabricate a series of small, unpiloted experimental vehicles that will fly up to 10 times the speed of sound.

Hyper-X's maiden flight will be the first time a non-rocket engine has powered a vehicle in flight at hypersonic speeds, which are above Mach 5 (equivalent to about one mile per second or approximately 3,600 miles per hour at sea level). A booster rocket will carry each experimental vehicle to its flight-test speed and altitude, where it will be launched to fly under its own power.

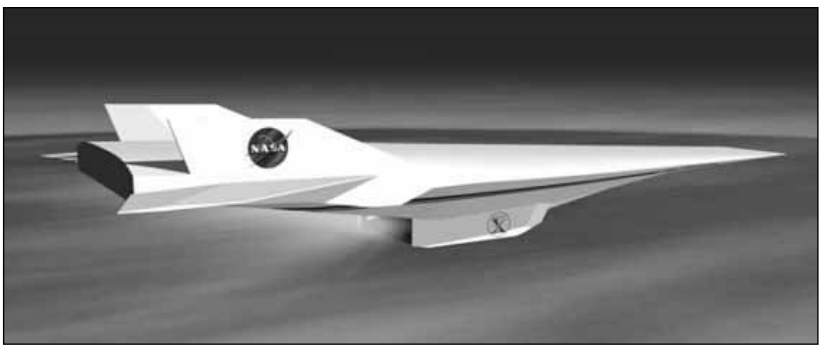
NASA's Langley Research Center will manage the project, while NASA's Dryden Flight Research Center will conduct flight tests. Hyper-X's other industry team members are Boeing North American, Inc., Seal Beach, California; GASL, Inc., Ronkonkoma, New York; and Accurate Automation Corp., Chattanooga, Tennessee.

The first of four Hyper-X vehicles is scheduled to fly in early fiscal year 1999. The Hyper-X contract is worth about $33.4 million.

MicroCraft will provide fabrication and flight-test support for the four research vehicles and one research vehicle-to-booster adapter for mating the research vehicles to the nose of an expendable booster rocket. Each vehicle will be approximately 12 feet long, with a wing span of about five feet.

The Hyper-X will demonstrate hydrogen-powered, "air-breathing" propulsion systems that could be applied in vehicles ranging from hypersonic aircraft to reusable space launchers. A rocket carries its own oxygen for combustion. The Hyper-X will burn oxygen in air scooped from the atmosphere. Thus, air-breathing hypersonic vehicles should carry more payload and/or offer longer range than equivalent rocket-powered systems.

The Hyper-X project will demonstrate hypersonic propulsion technologies.



For more information about the Hyper-X project, contact Vince Rausch at Langley Research Center. 757/864-3736, 757/864-8319, *V.L.Rausch@larc.nasa.gov* Please mention you read about it in *Innovation*.

Microgravity Comes Down to Earth

RESEARCH IN SPACE HAS ITS FIRST U.S. center on Earth. NASA's Lewis Research Center has signed a cooperative agreement with Case Western Research University (CWRU) and the Universities Space Research Association (USRA) to advance microgravity research in fluid physics and combustion science through the National Center for Microgravity Research on Fluids and Combustion.

The new center, to be located at CWRU's School of Engineering, is the first national center dedicated to microgravity research. This research is critical for carrying the space program into the next century and achieving the promised scientific and economic payoffs from the International Space Station. It also could lead to more efficient power generation, pollution abatement, improved manufacturing processes and biomedical innovations on Earth.

NASA will provide $17.8 million in funding over the next five years to support the center. The university-based science community will own and operate the center through USRA, a consortium of 80 colleges and universities, including CWRU.

"The National Center for Microgravity Research on Fluids and Combustion represents a commitment to our goal to strengthen the partnership between NASA and our nation's research community in universities and industry so that together we can increase the scientific and economic payoffs from NASA's Microgravity Science Program," NASA Administrator Daniel Goldin said.

The center will develop a pool of highly skilled microgravity investigators who can exploit the unique capabilities of the International Space Station to conduct world-class research that is impossible to study in ground-based laboratories. The center also will enhance the value of microgravity research by:

- Identifying and nurturing new research areas
- Transferring information, data and technology to industry
- Supplying technologies for NASA's Human Exploration and Development of Space Enterprise
- Spurring interest among tomorrow's scientists through programs designed for students in grades K through 12

The center's researchers will have access to unique equipment and facilities, such as the drop towers at Lewis, which test the effects of short-term microgravity on experiments. They also will establish an interactive network with other universities and industry to encourage their use of the capabilities and facilities at Lewis.

Center researchers will provide scientific and engineering support to principal investigators conducting microgravity research. They also will contribute onsite scientific support to principal investigators and flight hardware developers during the design, development and operation of flight experiments and during the analysis and dissemination of flight research results. ✿

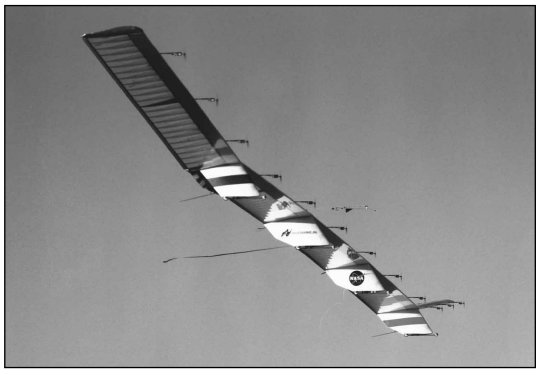
For more information, contact Simon Ostrach, director of the National Center for Microgravity Research on Fluids and Combustion. 216/368-2942 216/368-6455, *sxo3@po.cwru.edu* Please mention you read about it in *Innovation.*

Centurion Will Fly at 100,000 Feet

SIMI VALLEY, CALIFORNIA, AERONAUTICAL engineers are developing the Centurion—an aircraft they believe will push solar-powered aircraft concepts to new heights. AeroVironment Inc. engineers are designing Centurion to fly at a targeted altitude of 100,000 feet. The company is developing this concept as a member of NASA's Environmental Research Aircraft and Sensor Technology (ERAST) program, sponsored by the Dryden Flight Research Center.

Similar to its predecessor, the AeroVironment-developed Pathfinder, the Centurion will be an ultralight flying wing with multiple electric motors along its wing span. It is powered by solar cells spread across the wing's upper surface. The Centurion's wing span, however, will be more than twice that of the Pathfinder.

John Del Frate, Dryden's ERAST deputy project manager, said recent flight tests of a quarter-scale battery-powered model have answered questions about the Centurion's aerodynamics and stability. "We saw it fly, and it flew quite well," said Del Frate. "It has given us confidence that we can go ahead with the design of the full-scale vehicle. Technology in almost every aspect of the vehicle design will be used to maximize overall vehicle performance."



The early morning sunlight highlights a battery-powered, quarter-scale model of the Centurion solar-electric flying wing during flight tests over California's high desert.

"We'll take the data from these flights and incorporate them into the design of the full-scale proof-of-concept vehicle," said Bill Parks, the Centurion's chief designer and operations manager for subscale flight tests. "We're essentially scaling the aircraft up, designing new airfoils that are more efficient for high altitudes and optimizing the systems," said Rik Meininger, AeroVironment's Centurion project manager.

Cost and efficiency considerations have driven building and flying a subscale model, then a full-scale prototype, before developing the final solar-powered Centurion. "We find that we can make configuration changes very quickly and very cost-effectively, then immediately test it and come back and change if necessary," Meininger said. "It allows us, in a very short period of time, to get a lot of test data, and also do the risky things that normally you wouldn't want to do with a full-scale aircraft. By the time we get to the final aircraft stage, we should only be doing minor changes and fine-tuning for optimization."

The Centurion will be designed to reach 100,000 feet altitude for about two hours while carrying a 200-pound payload of scientific sensors. It will span 210 to 240 feet.

The Centurion is one of several unpiloted aircraft being developed under NASA's ERAST program. The goal of ERAST is to develop aeronautical technologies that will lead to the development of a new family of high-flying remotely piloted aircraft for scientific missions. The development of the technology necessary to make the Centurion successful and the lessons learned from the flight testing will be used directly to improve the performance of this class of vehicles. Although specific science missions have not yet been identified, it is expected that atmospheric sampling capability will be desirable. ✿

For more information about the Centurion, contact Fred Brown at Dryden Flight Research Center. 805/258-2663, *fred.brown@dfrc.nasa.gov* Please mention you read about it in *Innovation.*

SMALL BUSINESS INNOVATION RESEARCH

SBIR/STTR Update

STTR Phase I Proposals Number 215

NASA RECEIVED 215 SMALL BUSINESS TECHnology Transfer (STTR) program proposals during the 1997 STTR solicitation. Research topics include Earth remote sensing, advanced technology for space science, human exploration and development of space, general aviation, advanced space transportation, and nondestructive evaluation of material properties and structural integrity.

NASA anticipates selecting approximately 30 to 35 Phase I projects from this solicitation. Awards will be announced by mid-July.

STTR awards contract to small businesses for cooperative research and development with a research institution through a uniform, three-phase process. While modeled after the Small Business Innovation Research (SBIR) program, STTR is a separately funded activity.

STTR differs from SBIR in several important aspects. It is a small program authorized for three years beginning in fiscal year 1994. The planned funding set-aside for fiscal year 1997 is 0.25 percent of the external research and development budget, one-tenth of the amount for SBIR. The technical scope also is limited.

Offerors must be teams of small businesses and research institutions that will conduct joint research. Research institutions are nonprofit research organizations, federal laboratories or universities. STTR's goal is to transfer technology developed by universities and federal laboratories into the marketplace through small business entrepreneurship. The small business and its partnering institution are required to sign an agreement on how they will share intellectual property.

Phase I STTR projects receive up to $100,000 for one year. Phase II projects are limited to $500,000 for two years.

Visit *http://sbir.gsfc.nasa.gov/SBIR.html* to learn more about STTR.

NASA PHASE II ADDITIONAL SELECTION DISTRIBUTIONS

State	Selections	Firms
California	4	4
Connecticut	1	1
Florida	2	2
Iowa	1	1
New Hampshire	2	1
New York	1	1
Texas	1	1
Virginia	1	1
Wisconsin	1	1

SELECTION DISTRIBUTION BY NASA FIELD CENTER

NASA Centers	Awards	Firms
Ames Research Center	1	1
Dryden Flight Research Center	1	1
Goddard Space Flight Center	1	1
Jet Propulsion Laboratory	2	2
Johnson Space Center	2	2
Kennedy Space Center	1	1
Langley Research Center	1	1
Lewis Research Center	1	1
Marshall Space Flight Center	2	2
NASA Headquarters	1	1
Stennis Space Center	1	1

NASA Selects Phase II Projects

NASA HAS SELECTED 14 ADDITIONAL research proposals for negotiating Phase II contract awards through NASA's Small Business Innovation Research (SBIR) program. The selected projects have a total value of approximately $8.4 million. They will be conducted by 13 small, high-technology firms in nine states. These additional selections were made possible by a change in the fiscal year 1997 SBIR program funding plan.

SBIR stimulates technological innovation, increases the use of small business in meeting federal research and development needs, and increases private-sector commercialization of the results of federally funded research. A list of the awards may be accessed on the Internet (*http://sbir.hq.nasa.gov/SBIR.html*).

SBIR contractors completing Phase I projects initiated in 1995 submitted 277 proposals, and 170 were selected previously. These additional projects all have met SBIR Phase I objectives, and they all are feasible research innovations that meet NASA needs. The additional selections were taken from the original recommendation list.

Phase II continues the development of the most promising Phase I projects. Selection criteria include technical merit and innovation, Phase I results, value to NASA, commercial potential and company capabilities. Funding for Phase II contracts may be up to $600,000 for a two-year performance period.

The NASA SBIR Program Management Office is located at the Goddard Space Flight Center, with executive oversight by NASA's Office of Aeronautics and Space Transportation Technology at NASA Headquarters. Individual SBIR projects are managed by NASA Field Centers and the Jet Propulsion Laboratory. ✿

For more information, contact Paul Mexcur at Goddard Space Flight Center. 301/286-8888, *paul.mexcur@pop700.gsfc.nasa.gov* Or contact Carl Ray at NASA Headquarters 202/358-4652, *cray@hq.nasa.gov*
Please mention you read about it in *Innovation.*

Hale-Bopp Observations Surprise Astronomers

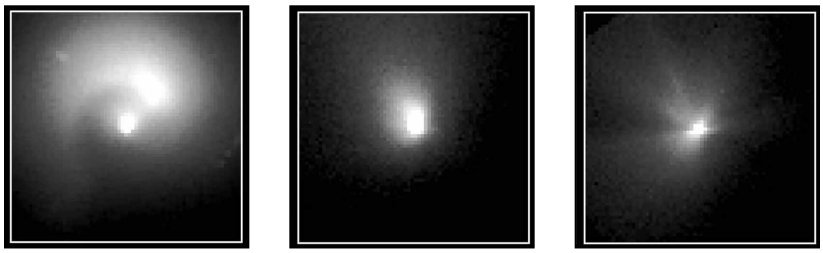
AN UNPRECEDENTED YEAR-LONG STUDY OF Comet Hale-Bopp, using two NASA observatories—the Hubble Space Telescope and the International Ultraviolet Explorer—has led to some surprising findings. Astronomers found that different ices in the nucleus seem to be isolated from each other. They also reported seeing unexpectedly brief and intense bursts of activity from the nucleus. The Hubble observations suggested the nucleus is huge (19 to 25 miles across).

"Hale-Bopp will probably provide the most revealing portrait of the workings of a cometary nucleus since the spacecraft missions to Halley's Comet in 1986," said Johns Hopkins astrophysicist Dr. Harold Weaver, who led a team of scientists who published their findings in a recent issue of *Science*. "This is a unique opportunity; we have never had the chance to examine a comet in this much detail, over this large a range of distance from the Sun."

Astronomers unexpectedly caught the comet going through a sudden brief outburst during the observations that began in August 1995. The dust spewed from the nucleus increased at least eight-fold in just over an hour. "The surface of Hale-Bopp's nucleus must be an incredibly dynamic place, with 'vents' being turned on and off as new patches of icy material are rotated into sunlight for the first time," Weaver said.

Astronomers also found that water ice turns directly from a frozen solid into a gas at a different rate than trace ices, implying that those components are not contained within water on the comet. This conclusion is further supported by Hubble data showing the rate at which dust left the nucleus was much different than the sublimation rate of water. Astronomers viewing the comet's images from Hubble estimate its nucleus at 19 to 25 miles in diameter. The average comet's nucleus is no more than about three miles in diameter. The comet or asteroid that struck Earth 65 million years ago, possibly causing the dinosaurs' extinction, was about six to nine miles across.

Hale-Bopp was unusually bright when it was well outside Jupiter's orbit, giving scientists their best view ever of the changes in a comet's nucleus as it gets closer to the Sun. Those changes provide information about the composition and structure of comets, which are believed to be remnants of the Solar System's formation. Learning more about comets could provide important information about the materials and processes that formed the Solar System. ✹



This is a series of Hubble Space Telescope observations of the region around the nucleus of Hale-Bopp.

For more information, contact Dr. Harold Weaver at Johns Hopkins University. 410/516-7343. Or contact Donald Savage at NASA Headquarters. 202/358-1547, *dsavage@hq.nasa.gov* Please mention you read about it in *Innovation.*

SPACE EXPLORATION SCORES HIGH

A national survey by the Council for Excellence in Government indicates that promoting space exploration is the only one of 16 tested items about which a plurality of Americans say the federal government has been very successful.

"This survey demonstrates again the importance Americans place on exploration and discovery," NASA Administrator Daniel Goldin said, "and their belief that one of the most important roles of the federal government is to help push back the boundaries of knowledge. NASA is not only a crucial investment in our national future—it is also a tangible symbol to the American people of the greatness to which we aspire."

Goldin said NASA is gratified to learn from this survey that it has been successful in meeting the American public's needs. "NASA's original charter mandates that the agency widely disseminate the results of its activities," Goldin said. "As a result, the public has shared these experiences and many feel a sense of direct ownership or involvement in NASA's programs. This is how it should be—NASA's programs are, indeed, their programs." ✹

For more information about the poll, contact the Council for Excellence in Government. 202/728-0418. Please mention you read about it in *Innovation.*

NASA Selects 39 Minority Institution Partners

NASA HAS SELECTED 39 MINORITY institutions to receive 65 Partnership Awards intended to expand educational opportunities and enhance diversity in the NASA-sponsored research and education community. The selected institutions are from 17 states, the District of Columbia and Puerto Rico. The awards are for two years, with a maximum of $200,000 per minority institution.

The 39 institutions were chosen by the Office of Equal Opportunity Programs (OEOP) in collaboration with NASA Headquarters program offices. The concept papers were submitted through the NASA Centers and the Jet Propulsion Laboratory.

Papers were evaluated by review panels and submitted to NASA Headquarters for final selection. The program's goals are to:

- Strengthen the partnerships between minority institutions and NASA's Strategic Enterprises and Field Centers, America's aerospace industry, and other educational institutions
- Develop projects that are unique, innovative and outside of the usual NASA Minority University Research and Education Program's competitive opportunities, with the potential for long-term support from other sources

NASA received more than 200 concept papers. The institutions submitted their concept papers as research projects, educational projects or a combination of both. The complete list of the selected institutions may be found on the World Wide Web. See the OEOP's Minority University Research and Education Program Home Page at *http://mured.gsfc.nasa.gov/* ✿

For more information, contact Sonja Maclin at NASA Headquarters. 202/358-1761, *sonja.maclin@hq.nasa.gov* Please mention you read about it in *Innovation.*

THE UNITED STATES MARKS YEAR IN SPACE

March 22 marked the one-year anniversary of a continuous U.S. presence in space, which began with the launch of astronaut Shannon Lucid aboard the Space Shuttle *Atlantis* on the STS-76 mission to the *Mir* space station. Astronauts John Blaha and Jerry Linenger have followed in Lucid's footsteps, conducting continuous scientific experiments aboard the Russian complex as a precursor to the development and occupancy of the International Space Station.

Linenger remained on board until mid-May when he was replaced by astronaut Mike Foale, who, in turn, will be replaced by astronaut Wendy Lawrence in September. The final U.S. astronaut scheduled for *Mir* is David Wolf in early 1998.

Former astronaut Norm Thagard was the first U.S. astronaut to live and work on *Mir* for four months in 1995. Lucid spent a U.S.-record 188 days in space. ✿

Two Centers Focus on Humans in Space

BAYLOR COLLEGE OF MEDICINE WILL LEAD NASA's new National Space Biomedical Research Institute. NASA also has selected Lawrence Berkeley National Laboratory to serve as a NASA Specialized Center of Research and Training (NSCORT) to research the biological effects of exposures to galactic and cosmic radiation.

The National Space Biomedical Research Institute will conduct focused biomedical research necessary to support human health in space exploration and development. The pilot program consists of a national consortium of premier academic and research organizations that will develop the solutions to medical risks associated with extended human space flight.

NASA and Baylor are expected to sign a five-year cooperative agreement with three five-year extensions in June. The 20-year agreement is worth approximately $145 million. The Johnson Space Center will sponsor the institute, making available to Baylor NASA's considerable knowledge and expertise in biomedical research and human space flight and the associated facilities and assets that have been developed over more than 35 years of human space flight.

The institute will maintain the scientific excellence of NASA's applied biomedical research through the scientific community's greater involvement in NASA's overall research program. Members of the National Space Biomedical Research Institute consortium are Harvard Medical School, Johns Hopkins

University's Applied Physics Laboratory, Massachusetts Institute of Technology, Morehouse School of Medicine, Rice University and Texas A&M University.

The institute's objectives include:

- Implementing a research plan to develop the knowledge and technologies required for long-duration space flight, including specific countermeasures
- Disseminating knowledge to the scientific community
- Facilitating science community access to NASA's space biomedical research expertise and facilities
- Transferring technology development and knowledge to the private sector

Research at the newest NSCORT will help define radiation risks experienced by space travelers and to develop effective methods to limit these risks. NASA plans to award the center approximately $1 million a year for five years. Lawrence Berkeley's selection is a competitive renewal award after an initial and very successful five-year period. Colorado State University is a collaborating partner.

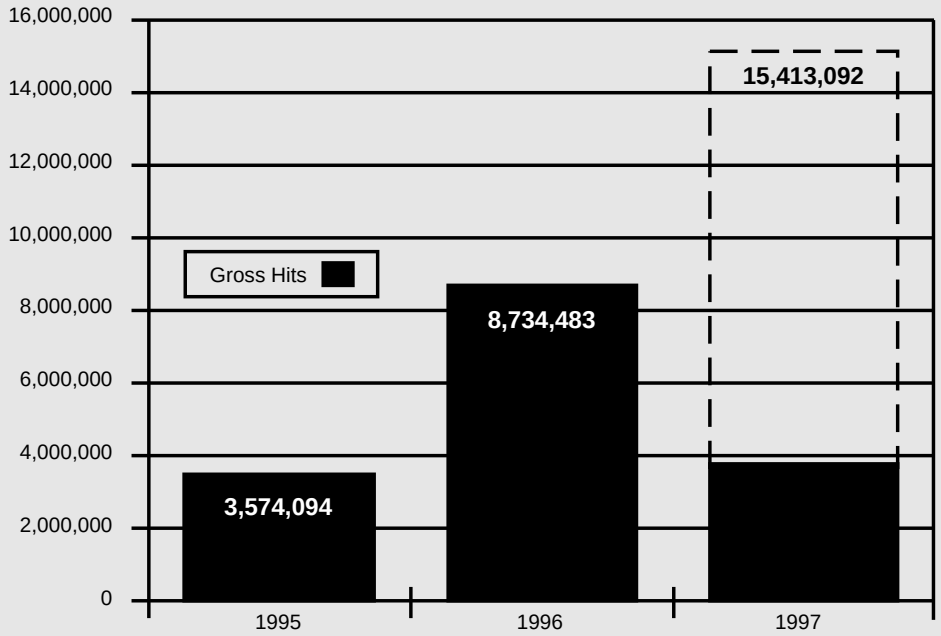
Other NASA-funded NSCORTs include Northwestern University Medical School, vestibular research; Ohio State University, plant biology; University of Texas, Southwestern Medical Center, integrated physiology; Purdue University, bioregenerative life support; and Kansas State University, gravitational studies in cellular and developmental biology. ✿

For more information, contact Michael Braukus at NASA Headquarters. 202/358-1979. Please mention you read about it in *Innovation.*

MEASURES AND METRICS

On-Line NASA Commercial Technology Network
World Wide Web Usage/Gross Hits Per Year

Private/public sector usage soars, with an average annual growth rate of 110 percent. This is an increasingly effective information resource and electronic marketplace for technology commercialization, facilitating public awareness, technology sourcing and partnership.



Note: Gross hits are defined as the total number of all files requests that are registered on a web site. Projected gross hits for 1997, as shown by the dotted line, are based on first-quarter actuals. Go to *www.nctn.hq.nasa.gov* to enter the network

Technology Opportunity Showcase *highlights some unique technologies that NASA has developed and that we believe have strong potential for commercial application. While the descriptions provided here are brief, they should provide enough information to communicate the potential applications of the technology. For more detailed information, contact the person or office listed. Please mention you read about it in* ***Innovation.***

Telemedicine

Prototype Internet Access Model

NASA's Langley Research Center, as part of its effort in the High Performance Computing and Communications/Information Infrastructure Technology and Applications program, has developed a prototype Internet access model that allows an entire local area network (LAN) of computers to connect to the Internet using only a standard, analog telephone line. By using a powerful network server to provide numerous functions for the LAN and using an intelligent network-based disk caching scheme, the cost of connecting to the Internet has been reduced by up to 80 percent over standard connectivity solutions for public schools in Virginia's Tidewater region. The model is scalable with up to 253 computers connected to the Internet simultaneously. Also, as demand dictates, the analog phone line can be replaced by a higher speed digital connection.

Lossless DCT (Discrete Cosine Transform)

NASA's Goddard Space Flight Center has developed Lossless DCT (Discrete Cosine Transform)-based Lossy algorithms that can be used for the analysis of medical images. The Lossless algorithm is an extension of the Rice algorithm that allows the compression of low entropy as well as normal and high entropy images. This algorithm is currently under consideration by the Consultative Committee on Space Data Systems to become an international space standard for lossless compression. The Lossy algorithm uses hybrid transform to reduce blocking distortions inherent in two-dimensional DCT. This system employs an adaptive encoder, which reduces the overhead associated with Hoffman code tables.

Registration and Data Fusion Tools

NASA's Jet Propulsion Laboratory has developed registration and data fusion tools designed originally to emerge tomographic, elevation and seismic data sets gathered from satellites and distribution sensors. The laboratory is currently adapting these tools for clinical medicine for fusing volumetric data sets from CT, MRI, PET and SPECT scanners. Pattern recognition algorithms also have been developed that can automatically classify and segment various regions of a fused volumetric medical image as normal or abnormal, based on histology-confirmed training data. This technology has numerous applications in oncology, orthopedic surgery and opthalmology.

ROSS 3D Reconstruction Software

This Ames Research Center technology, originally designed for use with biological cells, tissues or organs, allows for the reconstruction of any complex three-dimensional (3D) object that can be imaged in sections or layers by physical, optical, sound or other methods. Unlike other sectional modeling systems, the ROSS 3D Reconstruction Software acquires data directly from the imaging source (confocal microscopy, electron microscopy, ultrasound, and so on) without the use of photo- or radio-sensitive films. Features of the software include the fastest means of capturing images from a transmission microscope or other imaging probe, automated calibration of microscope stage parameters during image capture, electronic acquisition of complete data sets, remote sharing of data and arbitrary sectioning capable of rendering complex, branched objects.

VSLI Implemented Neural Networks

The Jet Propulsion Laboratory has developed VLSI-implemented neural networks that perform motion estimation and image data compression for medical applications. The system processes video image data, transmitting only the nonredundant parts in an efficient data stream, and consists of a motion estimation processor and an image compression processor implemented by VLSI circuitry. The motion estimation neuroprocessor implements a neuro-network-based motion-estimation algorithm to achieve a high-speed, wide-range estimation of motions in images.

DCT Algorithms

NASA's Ames Research Center has developed DCT algorithms that minimize noise while maximizing compression. This performance is obtained by optimizing the DCT quantization coefficients at the threshold of visibility, taking into account luminance, veiling light, spatial frequency and special frequency-related conditions (pixel size, viewing distance and aspect ratio). This DCT model pools errors nonlinearly over the image to yield perceptual error. The model provides the maximum visual quality for a given bit rate. It also provides the user with a sensible and meaningful quality scale for other DCT-based algorithms.

For more information about these technology opportunities, contact Shaik Mazharullah at the National Technology Transfer Center. 800/678-6882, *smazharullah@nttc.edu* Please mention you read about it in *Innovation.*

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Moving Forward

NASA Field Centers

Ames Research Center
Selected technological strengths are Information Technologies, Aerospace Systems, Autonomous Systems for Space Flight, Computational Fluid Dynamics and Aviation Operations.

Bruce Webbon
Ames Research Center
Moffett Field, California 94035-1000
415/604-1754
bwebbon@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths are Aerodynamics, Aeronautics Flight Testing, Aeropropulsion, Flight Systems, Thermal Testing and Integrated Systems Test and Validation.

Eugene (Lee) Duke
Dryden Flight Research Center
Edwards, California 93523-0273
805/258-3802
duke@louie.dfrc.nasa.gov

Goddard Space Flight Center
Selected technological strengths are Earth and Planetary Science Missions, LIDAR, Cryogenic Systems, Tracking, Telemetry, Command, Optics and Sensors/Detectors.

George Alcorn
Goddard Space Flight Center
Greenbelt, Maryland 20771
301/286-5810
george.e.alcorn.1@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths are Near/Deep-Space Mission Engineering, Microspacecraft, Space Communications, Information Systems, Remote Sensing and Robotics.

Merle McKenzie
Jet Propulsion Laboratory
Pasadena, California 91109
818/354-2577
merle.mckenzie@ccmail.jpl.nasa.gov

Johnson Space Center
Selected technological strengths are Artificial Intelligence and Human Computer Interface, Life Sciences, Human Space Flight Operations, Avionics, Sensors and Communications.

Henry (Hank) Davis
Johnson Space Center
Houston, Texas 77058
281/483-0474
henry.l.davis@jsc.nasa.gov

Kennedy Space Center
Selected technological strengths are Emissions and Contamination Monitoring, Sensors, Corrosion Protection and Biosciences.

Gale Allen
Kennedy Space Center
Kennedy Space Center,
Florida 32899
407/867-8035
gale.allen-1@kmail.ksc.nasa.gov

Langley Research Center
Selected technological strengths are Aerodynamics, Flight Systems, Materials, Structures, Sensors, Measurements and Information Sciences.

Joe Heyman
Langley Research Center
Hampton, Virginia 23681-0001
757/864-6005
j.s.heyman@larc.nasa.gov

Lewis Research Center
Selected technological strengths are Aeropropulsion, Communications, Energy Technology and High Temperature Materials Research, Microgravity Science and Technology and Instrumentation Control Systems.

Ann Heyward
Lewis Research Center
Cleveland, Ohio 44135
216/433-3484
ann.o.heyward@lerc.nasa.gov

Marshall Space Flight Center
Selected technological strengths are Materials, Manufacturing, Non-destructive Evaluation, Biotechnology, Space Propulsion, Controls and Dynamics, Structures and Microgravity Processing.

Harry Craft
Marshall Space Flight Center
Huntsville, Alabama 35812
205/544-5418
harry.craft@msfc.nasa.gov

Stennis Space Center
Selected technological strengths are Propulsion Systems, Test/Monitoring, Remote Sensing and Nonintrusive Instrumentation.

Kirk Sharp
Stennis Space Center
Stennis Space Center, Mississippi
39529-6000
601/688-1929
kirk.sharp@ssc.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Joseph C. Boeddeker
Ames Technology Commercialization Center
San Jose, CA
408/260-6566

Dan Morrison
Mississippi Enterprise for Technology
Stennis Space Center, MS
601/688-3144

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
216/586-3888

Maria Clark
Florida/NASA Business Incubation Center
Titusville, FL
407/383-5200

Small Business Programs

Carl Ray
NASA Headquarters
Small Business Technology Transfer (SBIR/STTR)
202/358-4652
cray@hq. nasa.gov

Paul Mexcur
Goddard Space Flight Center
Small Business Innovation Research Program (SBIR/STTR)
301/286-8888
paul.mexcur@pop700.gsfc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the RTTC nearest you, call 800/642-2872.

Ken Dozier
Far West Technology Transfer Center
University of Southern California
213/743-2353

Dr. William Gasko
Center for Technology Commercialization
Massachusetts Technology Park
508/870-0042

J. Ronald Thornton
Southern Technology Applications Center
University of Florida
904/462-3913

Gary F. Sera
Mid-Continent Technology Transfer Center
Texas A&M University
409/845-8762

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
412/383-2500

Christopher Coburn
Great Lakes Industrial Technology Center
Battelle Memorial Institute
216/734-0094

David Moran
National Technology Transfer Center
Wheeling Jesuit University
800/678-6882

Doris Rouse
Research Triangle Institute Technology Applications Team
Research Triangle Park, NC
919/541-6980

NASA ON-LINE

Go to the **NASA Commercial Technology Network (NCTN)** on the World Wide Web at ***http://nctn.hq.nasa.gov*** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

Multimedia

COSMIC, NASA's partner for software technology transfer, is currently distributing via Pacific Hitech a set of five CD–ROMs of NASA engineering software programs. The CD–ROMs provide source code for more than 150 NASA programs in the areas of aeronautics, modeling, AI and tools, and flow and structure. For further information, or to order the CD–ROMs, go to *www.pht.com* or call 801/261-1024. To learn about COSMIC's full catalog of NASA software, go to *www.cosmic.uga.edu* or call 706/542-3265.

Events

The ***Air Force Small Business Innovation Research*** (SBIR) program will host a day-and-a-half workshop, August 7 and 8, at Wright-Patterson Air Force Base, Dayton, Ohio. Information about the SBIR program will be provided by the Ohio Department of Development, NASA's Lewis Research Center and the Air Force. One-on-one discussions will be available. For additional information, call 800/848-1300, ext. 3887.

1997 AIAA Defense and Space Programs Conference and Exhibit, September 23–25, Huntsville, Alabama, is sponsored by Boeing Defense & Space Group and the American Institute of Aeronautics and Astronautics. The conference will focus on current and future military space and NASA civil space program challenges and opportunities. NASA speakers include Wilbur Trafton, Associate Administrator for Space Flight; Wesly T. Huntress, Associate Administrator for Space Science; Gary Payton, Deputy Associate Administrator for Aeronautics and Space Transportation Technology; and Wayne Littles, Director of Marshall Space Flight Center. Some of the conference topics are: future critical programs for NASA, the Navy and the Army Aviation and Missile Command and Space and Strategic Defense Command; current and future space transportation programs; future plans for the space station; Army and Navy space technologies; and trends in Army tactical missile systems and missile defense technologies. For more information, call 800/639-AIAA, fax 703/264-7551, send e-mail to *custserv@aiaa.org* or visit *http://www.aiaa.org*

The ***Experimental Aircraft Association (EAA)*** will sponsor its 45th Annual EAA Fly-In Convention (aka Oshkosh Air Show) July 30–August 5, 1997, at Oshkosh, Wisconsin. This year, the NASA exhibits expand to a second building. Exhibits will focus on the role of NASA partnerships in meeting today's aeronautics and space transportation technology challenges. For more information, call 414/426-4800.

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